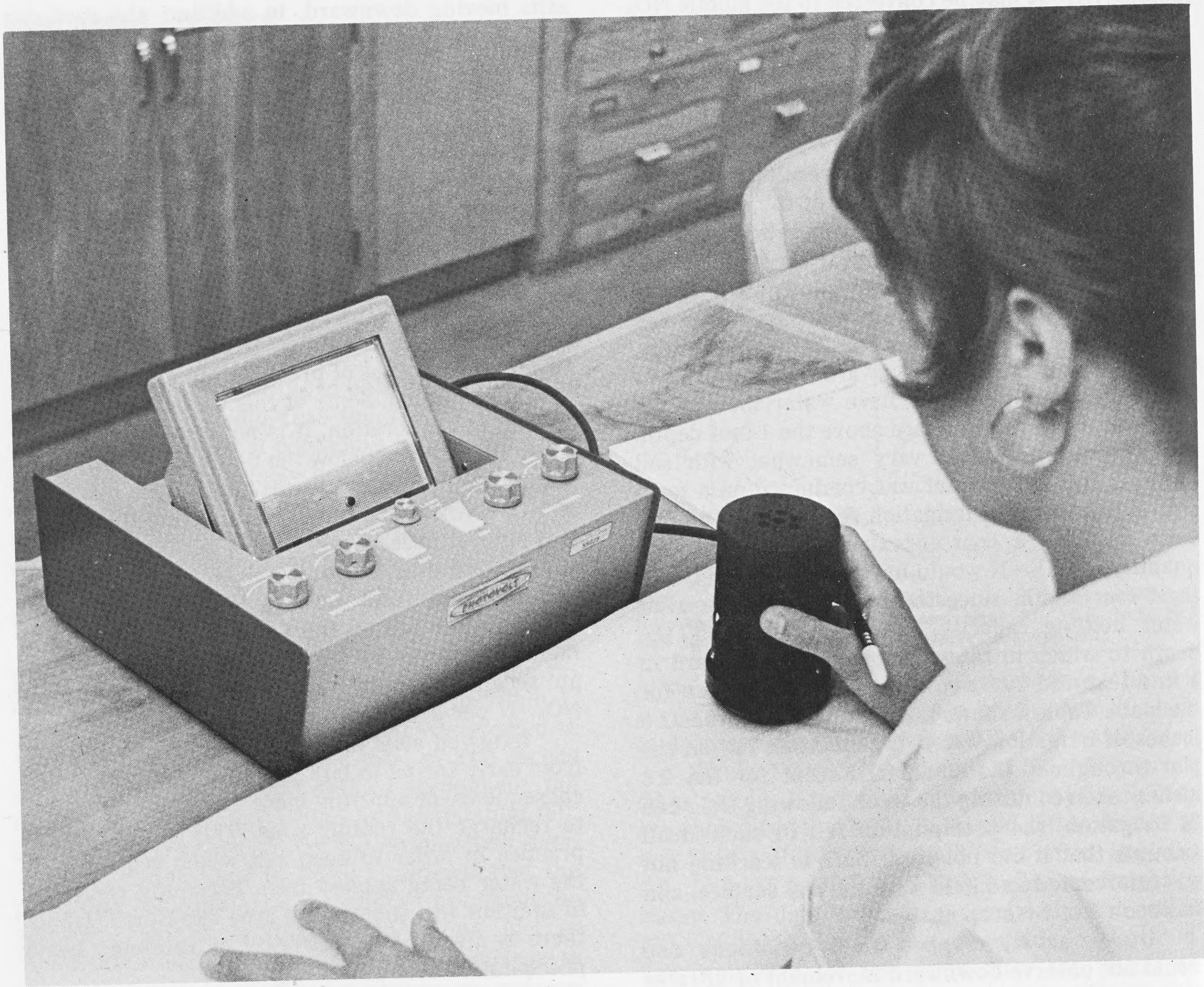

Mrs. Buckner tests the yellowness of fabric with the Photovolt reflection meter.

WATER QUALITY AND ITS EFFECT ON WHITE FABRICS

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How to prevent white fabrics from yellowing and to get longer service from fabrics are problems that concern North Dakota homemakers. Among the major laundry problems are water hardness as well as staining from iron and manganese.

To help the homemakers with laundry problems, a study was undertaken by the Textiles and

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Clothing Department in the College of Home Economics at North Dakota State University. The study was designed to identify factors in water that cause discoloration of white fabrics and to determine if these factors have other damaging effects on the fabrics such as loss of strength. Financial support for this work was obtained from the North Dakota Water Resources Research Institute and the College of Home Economics.

With the aid of home economics extension personnel, the Kindred area of Cass County, North Dakota, was selected for the study. Water in this area is hard and contains iron and manganese in sufficient quantity to cause staining of white fabrics. Extension Homemaker clubs were visited, and individuals who were interested in taking part in the study volunteered as cooperators. The majority of the 16 cooperators lived in the rural area; however, several individuals from the town of Kindred took part in the study.

Each cooperator was assigned a number. Six one-yard square white cotton test swatches were prepared for each cooperator. In each group of six swatches, one was unlaundered and remained in the textile laboratory for comparison purposes. The remaining five swatches were given to each cooperator.

The cooperators laundered the five swatches with a white load of clothes, using their usual laundry procedures and products with the exception of detergent, which was supplied through the water study. A swatch was withdrawn and returned to the textile laboratory for analysis after being laundered once, another after five times, the third after 10 launderings, the fourth after 15 and the fifth after 20 launderings.

Each cooperator supplied information regarding her source of water supply, water softening equipment, laundry equipment, amount of detergent, bleach, and other laundry aids used. All but four cooperators had water softening equipment installed and in use.

Both cold and hot water samples were collected from each cooperator's water supply. The cold water was taken at the well or before it went through any softening equipment. The hot water was taken as near the laundry as possible and after the water had gone through the softener if one was in use. This method of sampling showed if the softener was operating properly and if it was delivering what could be classed as soft water.

The samples were collected in the fall, winter and spring to determine if there was a seasonal change in water. The results of the water analysis indicated that in this particular area there was not a significant seasonal difference. The water was analyzed for hardness, iron, iron bacteria, manganese, alkalinity and pH.

Hardness

Hardness is caused by the water picking up calcium and magnesium salts as it seeps into the ground. The amount of water hardness is expressed as calcium carbonate in either parts per million or grains per gallon. One grain per gallon is equal to 17.1 parts per million. The water conditioning foundation classifies water supplies as follows:

	parts per million	grains per gallon
soft	0 - 17.1	0 - 1
slightly hard	17.1 - 60	1 - 3½
moderately hard	60 - 120	3½ - 7
hard	120 - 190	7 - 10½
very hard	over 190	over 10½

The cold water samples of all cooperators were found to be in the very hard classification. The hot water analyses indicated that in a number of cases the equipment used for softening was not producing water to the degree of softness that should be possible from the installations. Four cooperators had hot water in the very hard to hard range. The remainder of the cooperators had softened water; however, the waters were softened only to the point that they would be classified as moderately hard.

When soap is added to hard water, a gummy curd is formed. This curd imbeds itself among the fibers of textiles, dulling bright colors, turning white to yellow or gray and causing additional wear. Synthetic detergents do not form a curd when used in hard water, but must be used in larger amounts to be able to do the maximum cleaning. This results in a higher cost per washing load as well as causing a build-up of detergent in fibers. If detergents are used in smaller amounts than recommended for hard water, hardness salts in the water will interfere with the detergent's cleaning action, causing some dirt particles to be redeposited in the fabric. The result of this soil build up is stiffness and graying of the fabric.

The easiest method of removing hardness from water is by an ion exchange tank in which hard water flows through zeolite or other ion exchange resin. This process removes the minerals which cause the hardness. Such equipment can be purchased outright, subscribed to on a service basis or rented.

The shift from soaps to detergents has not lessened the need for softening water. Water softening equipment represents a financial investment; however, it is an economy when the damage caused by hard waters and minerals are measured in dollars. Studies have been made comparing advantages of softened water over hard water. The results indicated that wear life was increased and the price per wash was approximately 35 per cent less. Fabrics were softer and itching or irritation of skin was minimized.

Iron and Manganese

Iron and manganese in water also cause problems in the laundry process. Iron in water may remain in solution and the water will appear clear and colorless or it may be oxidized, causing the water to become red. Iron in either form causes yellowish-brown stains and manganese causes dark brown to black stains on fabrics. Staining can occur when iron in concentrations as low as 0.05 parts per million and manganese in 0.01 parts per million are present. The U. S. Public Health Service recommends that the sum of iron and manganese not exceed 0.3 parts per million.

All cooperators' water supplies contained iron in excess of 0.05 parts per million, the level at which staining in laundry may occur. The manganese content was also decidedly above the level that usually causes staining in white fabric.

If iron and manganese are not present in too large a quantity, they may be removed by an ion exchange water softener. When the quantity is excessive, it is advisable to install a chemical iron filter ahead of the softener. A softener-filter combination designed to remove iron and manganese from the water supply would prevent staining and yellowing of fabrics.

Because of the emphasis on whiteness in laundry, many homemakers rely on strong bleaches such as chlorine bleach to decolorize soil and remove stains. When stains are caused by iron and manganese, chlorine bleach should not be used. It not only fails to remove such stains, but actually intensifies the staining problem.

It is possible to remove the yellow caused by iron as well as iron and manganese stains from fabrics by using oxalic acid crystals, which are available at a drug store. The amount of crystals depends on the intensity of the stain. Usually one tablespoon of oxalic acid crystals in a quart of warm water will be effective. The following directions work for most fabrics: 1. Mix the solution in a plastic or glass container. 2. Let the stained fabric remain in the solution for two minutes, then rinse thoroughly and launder. Use rubber gloves to avoid skin irritation. This method of iron removal is not recommended for nylon.

In some instances it is advisable to use an oxygen type bleach. While an oxygen bleach does not restore whiteness to the same degree that a chlorine bleach does, it is compatible with iron and manganese and does help in maintaining whiteness of fabrics.

Iron in water also can be caused by microorganisms known as iron bacteria. These microorganisms grow in water containing iron and deposit the iron in a slime layer. The slime growths formed cut down flow rates, clog pipelines and other water handling equipment. The growths frequently break loose in large masses, creating rusty water that has an objectionable taste and odor.

The presence of iron bacteria can be determined by microscopic examination. Another way to check is to inspect the inside of the toilet flush tank. If it is red in color, there is iron present. If the flush tank walls have a gritty or grainy feel, it is most likely metallic iron. If there is slime coating, iron bacteria may be present.

A microscopic examination was done on the fall water collection and no iron bacteria were found to be present in any of the samples at that time.

Alkalinity and pH

Alkalinity refers to the amount of various alkalies in the water which are capable of neutralizing acids. All cooperators' cold and hot water supplies were found to have pH values between 7.0 and 8.8. This indicates that waters were alkaline rather than acidic.

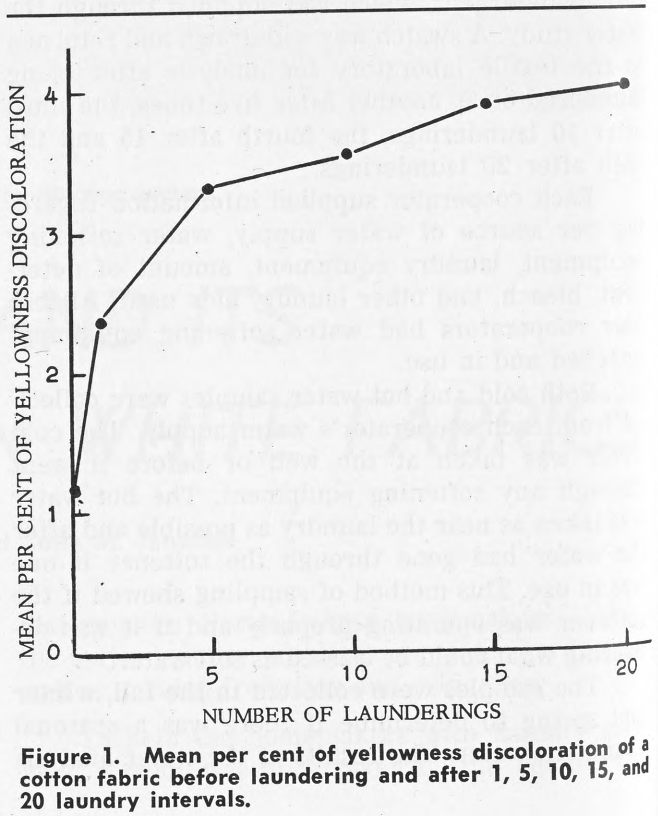

Figure 1. Mean per cent of yellowness discoloration of a cotton fabric before laundering and after 1, 5, 10, 15, and 20 laundry intervals.

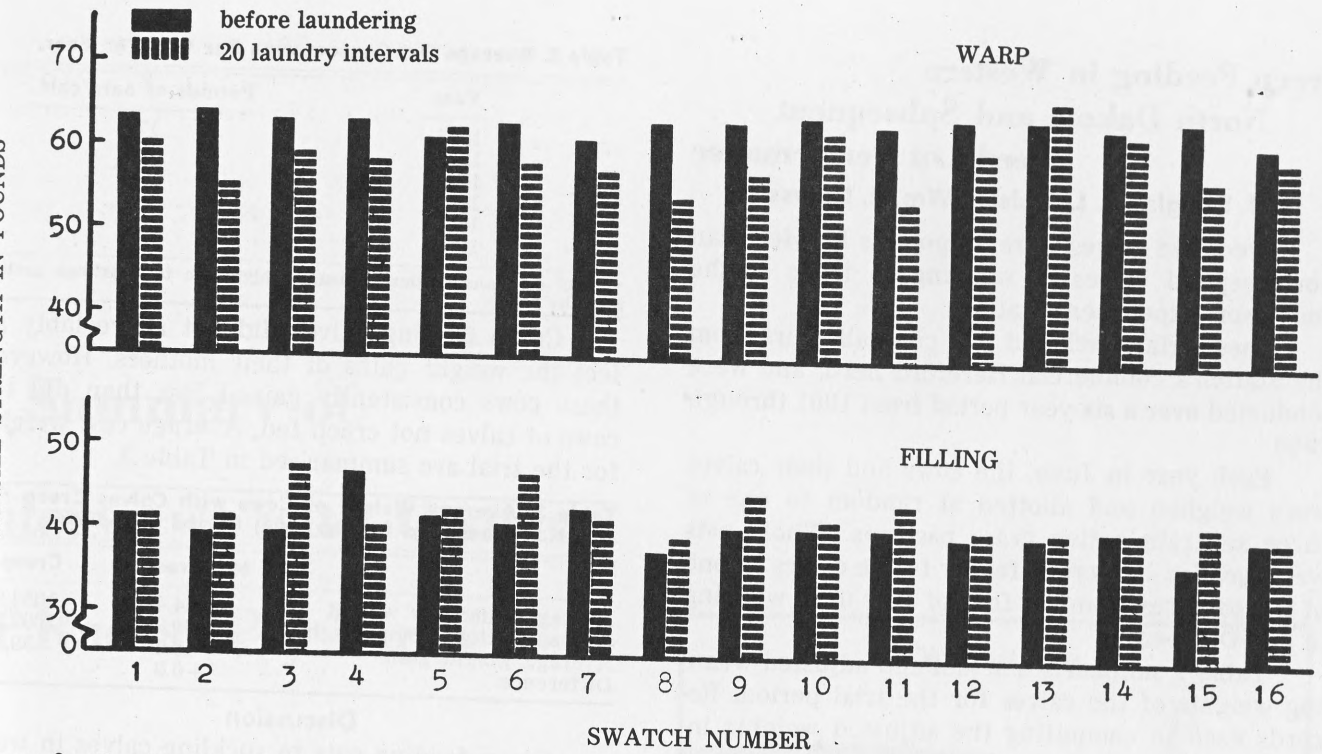

Figure 2. Tensile strength in pounds of a cotton fabric before laundering and after 20 laundry intervals.

Measuring Discoloration of the Fabrics

A Photovolt reflection meter was used to determine the whiteness of the unlaundered swatches and to measure the amount of discoloration of the laundered swatches.

Yellowness was calculated for each unlaundered and laundered swatch. The unlaundered swatches had an average yellowness value of 1.14 per cent. After the swatches had been laundered 20 times the yellowness discoloration ranged from 0.9 to 7.0 per cent, with the average discoloration being 4.03 per cent. This increase in yellowness may be seen in Figure 1. There was one instance in which the swatches did not show any discoloration. This cooperator used rain water, which was soft and contained very little iron and manganese.

The swatches showing the greatest increase in per cent of yellowness were laundered in moderately to very hard water. The waters also contained iron and manganese in levels above the limits of acceptability. The greatest increase in yellowing occurred after the first and fifth laundry intervals; however, the swatches did become yellower with each laundering.

Fabric Strength

The discoloration or yellowing of fabrics by minerals in a water supply is readily noticeable. In order to determine if these minerals had been detrimental to the fabric, tests were made for breaking strength.

After 20 launderings, all but two swatches showed a decrease in fabric strength in the lengthwise (warp) direction (Figure 2). The swatches having the greatest decrease in fabric strength had been laundered in hot water classified as very hard or over 10.5 grains per gallon of hardness.

The strength results in the crosswise (filling) direction indicated only a small amount of change and in some instances there had been an increase in strength. These results were influenced by the increase in thread count, thickness and weight of the fabric which takes place when shrinkage occurs.

Conclusions

1. There was no significant difference between waters sampled in the fall, winter and spring.
2. The water analyses indicated that in a number of cases equipment used for softening water was not producing water to the degree of softness that should be possible from the installation.
3. Water supplies in this area contained both iron and manganese in excess of the level which causes staining in laundering.
4. When iron and manganese are present in the water, chlorine bleach should be avoided.
5. White fabrics that were laundered in hard water containing iron and manganese became discolored during the first laundering and this discoloration increased with repeated launderings.
6. Tensile strength decreased in the lengthwise direction for most fabrics laundered in the very hard water classification.